

THE PHYSIOLOGICAL HYDRAULICS OF DROPSY, DIARRHŒA, SUPPRESSION OF URINE, AND DIABETES.

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A COMPARISON of the facts of dropsy, diarrhœa, suppression of urine, and diabetes, leads to the conclusion that there are certain physical phenomena which are common to these various morbid conditions; and the results of this comparison have both a physiological interest and a practical value.

The kidney is the chief natural outlet for superfluous liquid. A free imbibition of water is usually succeeded by a copious secretion of pale urine. The excess of water entering the blood-vessels finds a speedy exit by the renal waste-pipe. On the other hand, a suspended or greatly diminished action of the kidneys has for one of its most frequent results an accumulation of water in the system—a condition which is designated dropsy.

The physiology of acute renal dropsy is sufficiently simple and intelligible. The tubes of the kidney are choked by the products of acute desquamative nephritis, while the vessels are gorged with partially stagnating blood. The secretion of urine is scanty, and mingled with blood-materials. Consequently, the constituents of the urine, both solids and liquids, begin to accumulate in the blood, whence they are effused into the areolar tissue, and into the serous cavities. The patient has what is called general dropsy; the dropsy being the result of a conservative effort to expel from the blood the excess of water, and of urinary solids, which tend to accumulate there in consequence of defective action of the kidneys. The dropsical effusion is removed by a reversed action of the vessels. The congestion and inflammation of the kidney subside; the circulation through the kidney again becomes free; the inflammatory products are washed from the uriniferous tubes; and thus the function of the gland is restored. Then a copious secretion of urine, mainly excited by the diuretic action of retained urea, quickly removes the excess of water from the blood; the blood-vessels—capillaries and veins—take up the water that had been effused into the areolar tissue and the serous cavities; and, this fluid escaping by the kidneys, the dropsy is removed. This is the natural cure of dropsy. In some chronic cases, the free action of a diuretic upon the kidneys may be made to pump the water from the tissues, and thus remove a dropsical effusion.

Another mode in which dropsy may be artificially removed is by the action of a hydragogue purgative. Thus a dose of elaterium excites copious watery discharges from the bowel; the discharge of liquid tends to deprive the blood of its water; this in its turn leads to the absorption of the dropsical fluid from the tissues; and thus a copious purging may cure a dropsy. Sir Thomas Watson mentions the case of a man in whom a profuse purging, excited by intoxicating doses of rick punch, led to the disappearance of a large hydrocele in the course of one night. Here it is clear, as Sir Thomas remarks, "that the expenditure of serous liquid from one part led to its absorption into the blood from another." We act upon the same physiological principle when we endeavour to promote the absorption of dropsical or inflammatory liquid effusions into the pleura or the pericardium by the hydragogue action of purgatives and diuretics. We know that, if we can partially drain the vessels in one direction, they will strive to fill themselves from another source.

We are now prepared to understand what happens during the progress of choleraic diarrhœa. A morbid poison, having entered the blood, excites copious watery discharges from the stomach and bowels. The blood-poison excites the choleraic discharges from the alimentary canal, as sugar in the circulating blood excites a diabetic flux through the kidneys. The choleraic discharges, however copious, have no appreciable effect in thickening the blood; and the reason is not difficult to find. The soft tissues of the body, the muscles, the viscera, the areolar tissue, etc., contain four-fifths by weight of water—water which is not chemically combined with them; for, when the tissues are exposed to the air, this water is gradually given off by evaporation, and it can be rapidly extracted by pressing the tissues between folds of blotting-paper. Now, when water is drained off from the blood by the bowels, the water of the tissues passes through the walls of the capillaries into the veins; so that the volume and the liquidity of the blood are maintained by this compensatory process of absorption; while the loss of water by the soft tissues is indicated by the fact that, after death from choleraic diarrhœa, the weight of the solid viscera, especially that of the kidneys and the spleen, has been found to be appreciably lessened.

The rapidity with which absorption occurs in the subcutaneous tissue

is shown by the quick and powerful action of morphia and other narcotics when injected beneath the skin; and so rapid is the absorption of water from the tissues when the contents of the blood-vessels are escaping, that the blood which escapes towards the end of the operation of venesection has been found to be more watery and of lower specific gravity than that which flows when the vein is first opened. Here we have evidence that, while the blood is escaping from an open vein, a current of water quickly passes into the vessels from the soft tissues.

We have next to consider what happens when the choleraic discharges from the alimentary canal have ceased. The blood, as we have seen, has maintained its liquidity by borrowing water from the tissues, which are thus left comparatively anhydrous. This borrowed water has now to be restored by a reversed current of liquid. During the stage of active elimination from the blood through the mucous membrane of the alimentary canal, absorption by that surface is prevented by the outward current of liquid; but, when the vomiting and purging have ceased, liquids taken into the stomach are rapidly absorbed into the blood-vessels, and thence transferred to the tissues which have been partially deprived of their water. So great is now the demand for liquid by the tissues, and so strong is the current towards them, that for a period, varying in different cases from a few hours to several days, little or no urine is secreted; the main stream of water being into the dehydrated tissues—an exact reversal of the tide of liquid which flows from the tissues towards the alimentary canal while the vomiting and purging are in active progress.

The stream of liquid into the tissues may carry with it urea and other urinary materials, and thus may contaminate and poison the tissues. This tissue-poisoning is probably in part the explanation of the consecutive fever of cholera. On the other hand, we have evidence that when, in consequence of renal disease, the blood is contaminated with urine, a hydragogue purgative removes not only water, but also some urinary excreta from the blood, and thus counteracts the tendency to uræmic poisoning.

The surest way to restore the secretion of urine after a copious watery diarrhœa is to supply an abundance of liquid to the blood and the tissues through the stomach and through the skin by an occasional immersion in a tepid bath. If frequent vomiting interfere with the introduction of liquid through the stomach, tepid water may be injected into the bowel.

The urine which is first secreted after an attack of choleraic diarrhœa is almost always albuminous. This is a result of irritation and congestion of the kidney, excited by the same morbid poison which caused the diarrhœa. In most cases, the albumen quickly disappears from the urine; but in a comparatively few cases a congested and inflamed condition of the kidney may cause a fatal suppression of urine. This is the more likely to happen if brandy and opium have been freely given during the diarrhœa stage. This form of suppression of urine is best treated by purgatives, by leeches or cupping, and fomentations on the loins.

Here it may be well to remark that suppression of urine results from various causes, and therefore assumes different forms, requiring a varied treatment.

The liquid part of the urine is defective when there is profuse sweating or a copious watery discharge from the alimentary canal, or when after such discharges the tissues are reclaiming the water which they had given up to the blood during the continuance of the discharges. The solids of the urine are defective when, during the collapse of cholera, the circulation of the blood, and consequently the oxidation of the tissues, are greatly lessened. The urinary solids are products of oxidation. Lastly, both the solids and the liquid of the urine may be scanty or suppressed when the secretory power of the kidney is impaired by organic disease.

The copious secretion of urine by a diabetic patient causes thirst and a free imbibition of liquid. The sugar acts as a diuretic, and the kidney excretes the sugar, together with so much liquid as is required to dissolve and to wash out the sugar. The liquid required for this purpose is mainly obtained through the stomach; but it is a well-known fact that diabetic patients frequently pass by the kidneys more liquid than they drink.

Sir Thomas Watson mentions the case of a boy who had *diabetes insipidus*, and who, while restricted to a pint and a half of liquid a day, passed ten pints and a half of urine. Evidence to the same effect was obtained by weighing the boy at short intervals. Thus, on one occasion immediately after he had emptied his bladder, he was found to weigh 3st. 8lbs. 3dr. Three hours subsequently, having taken nothing in the interim, he weighed exactly a pound more. Then he voided a pound of urine, after which his weight was the same as at first, so that he must have absorbed; either through

the lungs or the skin, or both, a pound of liquid in the course of three hours. This rate of absorption would give eight pounds in the twenty-four hours: add to this the pint and a half of liquid allowed as a drink, and we have within a pint the amount of liquid that the boy actually passed within the period of twenty-four hours—namely, ten pints and a half. Now, since we have positive proof that a copious drain of liquid through the kidneys leads to the absorption of water from the air through the lungs and skin, it is probable that the same process of pulmonary and cutaneous absorption of water takes place in cases of profuse watery diarrhoea; and that this is one of the means by which the blood is enabled to maintain the normal proportion of its watery ingredients while water is rapidly escaping by the stomach and bowels.

We have a familiar illustration of the close relationship between the skin and the kidneys in the copious secretion of pale urine associated with suppression of the perspiration by the continuous application of cold to the surface; while, on the contrary, the urine is scanty when free perspiration results either from disease, as in the case of rheumatic fever, or from a high temperature of the air, or from active exercise. Again, the skin is dry and perspiration scanty when, as in a case of diabetes, an abundant stream of water is constantly escaping by the kidneys. In fact, as we have already indicated, the skin of a diabetic patient rather absorbs than secretes water.

It is manifest, from a consideration of the facts which we have now passed in review, that within certain limits, and while the circulation and respiration are unimpeded, the blood has a remarkable power of maintaining the normal proportion of its solid and liquid ingredients. Thus when, in consequence of defective action of the skin and kidneys, water is retained in the system, the excess of water, not being allowed to accumulate in the blood, is thrown into the tissues, which are thus flooded with water, and dropsy is the result. On the other hand, a copious drain of liquid from the blood, either through the alimentary canal or through the kidneys, causes a demand for water, which is met partly by the imbibition of liquids by the mouth, partly by the absorption of water from the tissues and through the pulmonary and cutaneous surfaces. Thus a copious drain of liquid may remove a dropical accumulation, or temporarily deprive the healthy tissues of their usual proportion of water; the blood meanwhile maintaining its normal composition.

In a paper on "Some Points in the Pathology of Cholera and Apnoea", which I published in the *British and Foreign Medico-Chirurgical Review* (April 1870), I have shown that the dark and treacherous condition of blood which occurs during the collapse stage of cholera is a consequence of the impeded circulation and respiration; this condition of blood being found alike in cases of cholera-asphyxia and in all forms of apnoea.

Thus it appears that, while circulation and respiration are unimpeded, profuse watery discharges tend to dry the tissues, but not to thicken the blood, on the other hand, blood-thickening results from impeded circulation and respiration—from asphyxia and apnoea—even when there has been little or no drain of liquid from the system.

SYPHILITIC INSANITY.*

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THE three following cases of syphilitic insanity, which came under my care in the Newcastle Asylum, are, I think, worthy of bringing before you as illustrative of the remote effects of the taint of syphilis.

CASE I.—J. S., a commercial traveller, aged 35, married, with children, was admitted into the Newcastle Asylum on April 16th, 1868. He had fair hair, blue eyes, and fresh complexion. His bodily condition and health were indifferent. He had led a very irregular life many years, and at one time suffered severely from syphilis. During the three months before admission, he had gradually become incapable of conducting business. He now believed himself persecuted by enemies, especially men residing at Bradford, with whom he had had business connexions. He said he heard them conspiring against him and wishing him ill. He was restless and irritable; frequently heard voices talking with him and about him; he understood all their plots. He slept fairly, but awoke much distressed, believing that he had been subjected to the most cruel processes during his sleep.

After residing in the asylum for a short time, he continued to be the subject of the most extraordinary hallucinations. He heard voices

which communicated to him the most foolish and absurd things, all which he firmly believed. He said he underwent nightly a kind of torture, which he called the "cylinder finish", and which he described as an excruciating process, by which his brains were whirled round with extreme velocity, mixed into a pulp, and replaced in his skull just in time for his awaking. This, he believed, was ordered by the doctor, who knew of everything that was done to him, and had the power of regulating the amount of his sufferings. He was also, he said, frequently put upon the wheel and drugged during the night; and, though he really slept well, he averred that all the time he was vividly sensitive to all the tortures which he thought he underwent. Gradually he became extremely irritable, fancied that insults were offered to him by all about him, secluded himself from the society of his fellows, refused food, was inclined to lie in bed, and threatened to commit suicide. He referred to his head as the seat of his sufferings, and complained of pain at the vertex. Occasionally he was persuaded to take the iodide of potassium in two-grain doses three times daily, but never so continuously as to give it a fair trial.

In the second year of his residence in the asylum, phthisis pulmonalis became developed, and then some improvement in his general health took place. He began to occupy himself in the joiner's shop, making toys for his children; and his actual sufferings seemed to obscure the abnormal sensations which so strongly affected him in the earlier period of his disease. Two years after his admission, he died. No *post mortem* examination was allowed by the friends.

CASE II.—D. T., a woman aged 50, married, without children, was admitted on April 10th, 1868. She was said to have led a dissolute life. She was very much emaciated and unhealthy; her nose was marked by cicatrices. She had suffered from syphilis, and had a bad sore on the leg. The circulatory and respiratory systems were healthy. She was of fair hair and complexion, ate well, and was said to sleep well. It was stated that she had been only a week insane.

On admission, she was in a state of dementia. She was perfectly bewildered, and evidently could not understand the events taking place about her. She answered very slowly any questions that were put to her, and seemed unable to understand when she was spoken to.

Shortly after admission, her mind became filled with singular and painful delusions. She fancied herself constantly persecuted by certain individuals, who day and night made it their business to annoy and hurt her. This they did by using the most ingenious machines, which were specially invented to torture. They were introduced into her body and brain, and worked by means of wheels. She averred that they burnt her brain, drew out her inside, cast her into the air, put their fingers into her, and so tormented her. This for the most part took place in the night; but, if she were allowed to remain in bed during the day, she complained of similar though not such severe treatment. At the same time she heard her tormentors talking together, consulting as to which was the most painful process they could invent. She also heard others remonstrating with them for treating the poor woman so cruelly. She as well saw faces which she recognised as old neighbours, and particularly the face of her principal tormentor, whom she supplicated to desist. The head was referred to as the seat of the pain.

During her residence in the asylum, she has every morning bitterly complained of her treatment during the previous night; and sometimes she gets into great excitement, and threatens to destroy herself occasionally. She refuses her food for days together, with that intent; and once, about a year after admission, was found by the night-nurse nearly strangled by a garter which she had twisted round her neck. She has often prayed the doctor to give her poison to end her sufferings.

She now (August 1870) continues to suffer from the same or similar delusions and hallucinations. At night, when the nurse shuts the door on her, the operations of her tormentors commence, and so they continue to persecute her all night. She says she is placed on a table and dissected; that her head is opened; and that all the time she sees and hears her tormentors inciting each other to treat her more and more severely. She occasionally receives her medical attendant with a storm of abuse, averring that he was present during the night, and aided her tormentors. The sores on her legs healed up under treatment by a solution of the bichloride of mercury. There has been no improvement of the mental symptoms of any duration, although she has undergone long courses of the iodide and bromide of potassium. The hydrate of chloral, in forty-grain doses, produces deep and long continued sleep, and seems to relieve the symptoms at the time; but there is no material change in the mental state of the patient.

CASE III.—P. H., aged 58, single, an Irish labourer, a Roman Catholic, was admitted into the Asylum on January 22nd, 1869. He had served some years in Portsmouth, and had led a very irregular life. He has fair hair and eyes, and is ruddy; he is blind of one eye from wound of the cornea. He has suffered from syphilis; but his general

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